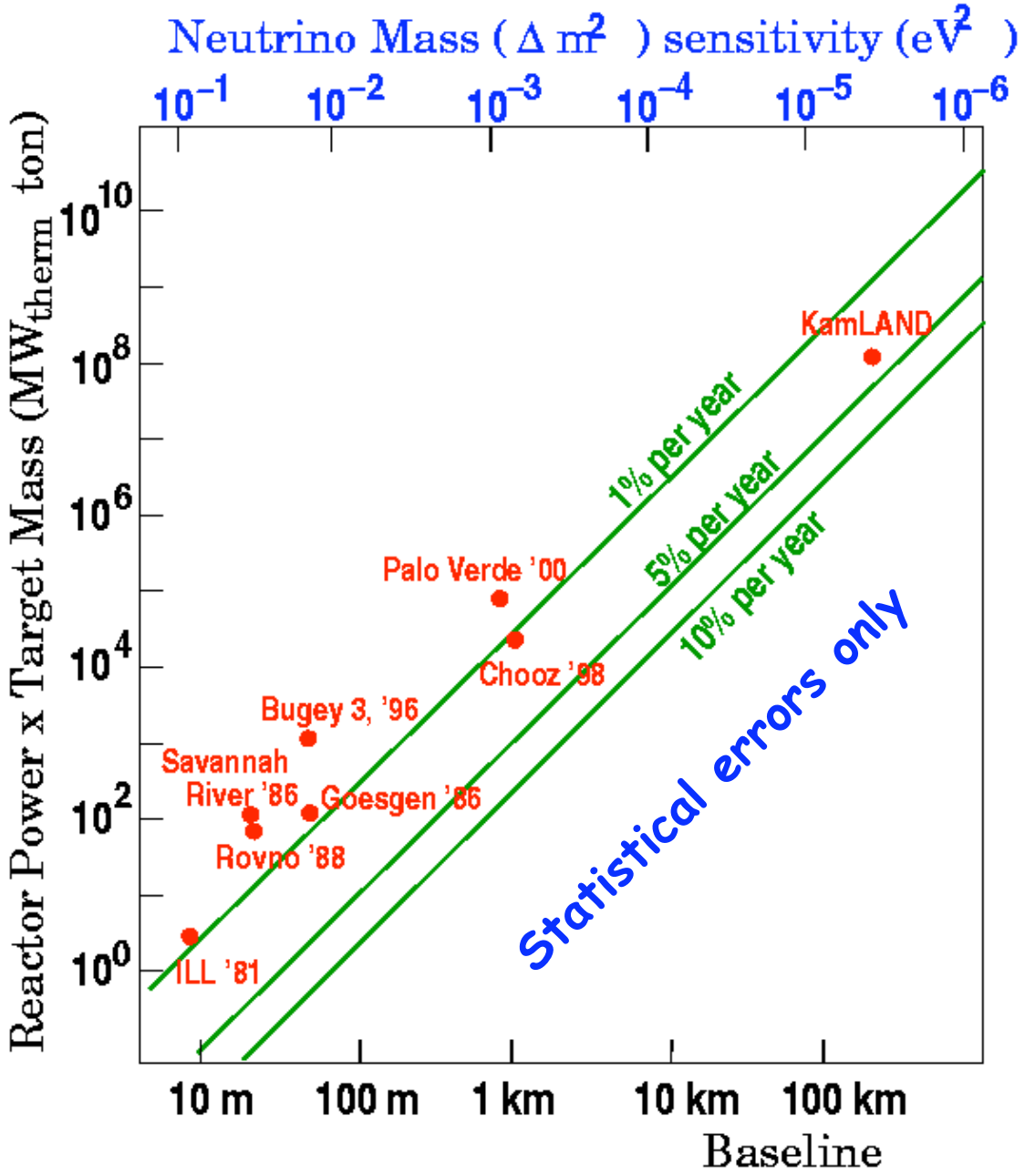
KamLAND

October 11, 2002

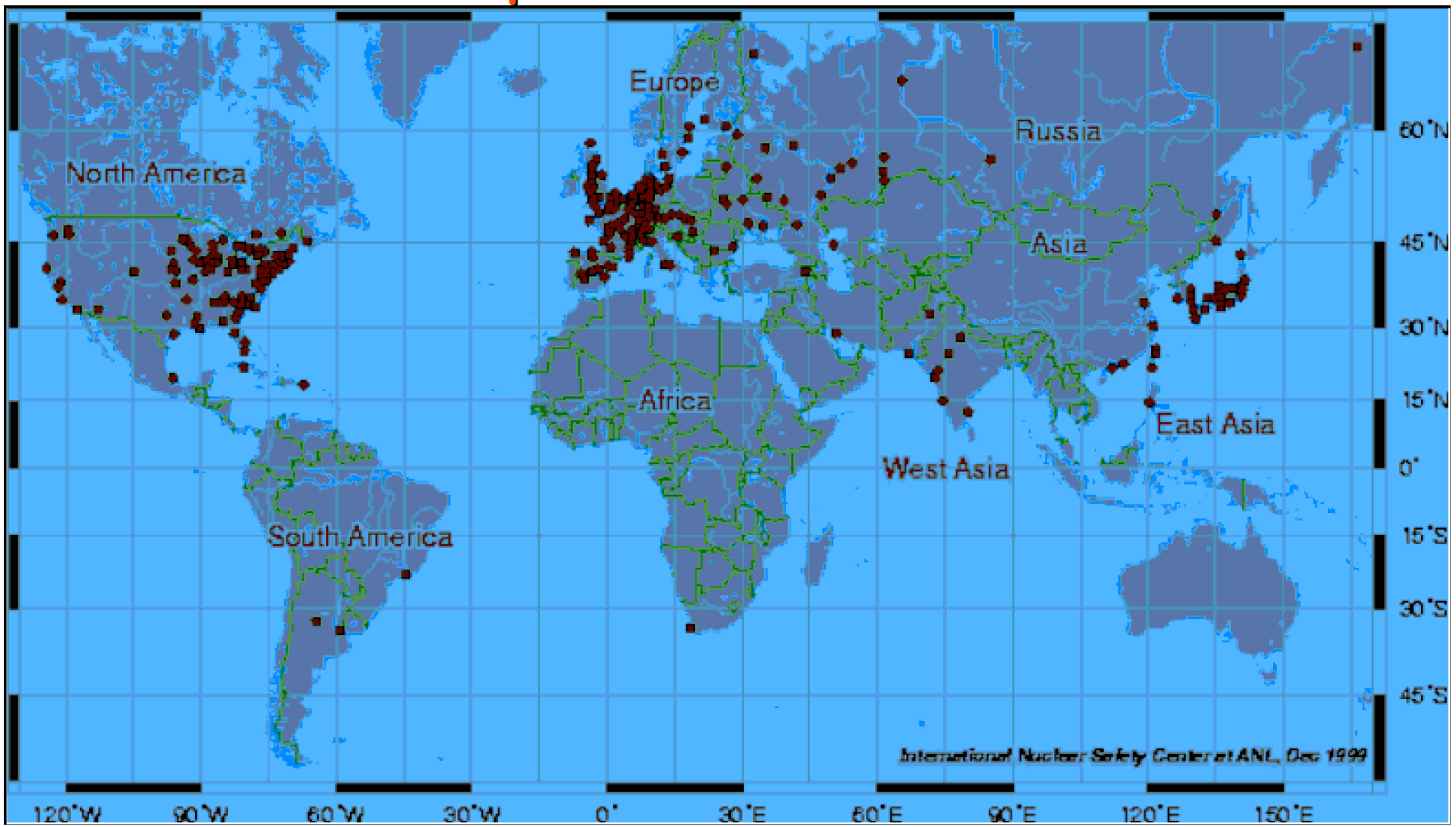
Status of KamLAND

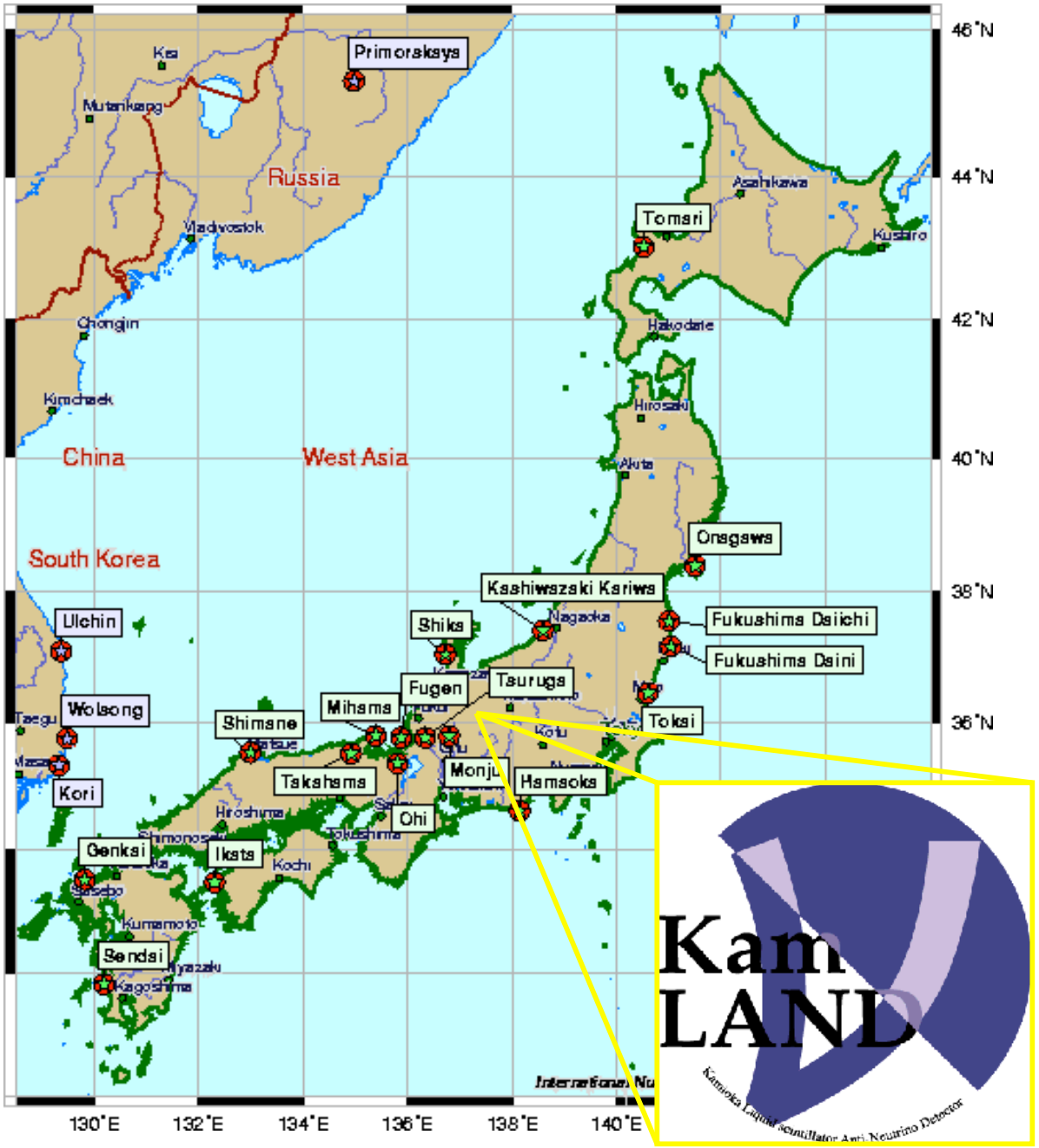
Presented by Glenn Horton-Smith (Caltech)
for the KamLAND collaboration

Designed to
test solar neutrino
oscillation parameters
on Earth (!)
KamLAND has a much
longer baseline
than previous
(reactor) experiments
...still quite a
difficult experiment



Only a few places in the World could host an experiment like KamLAND…



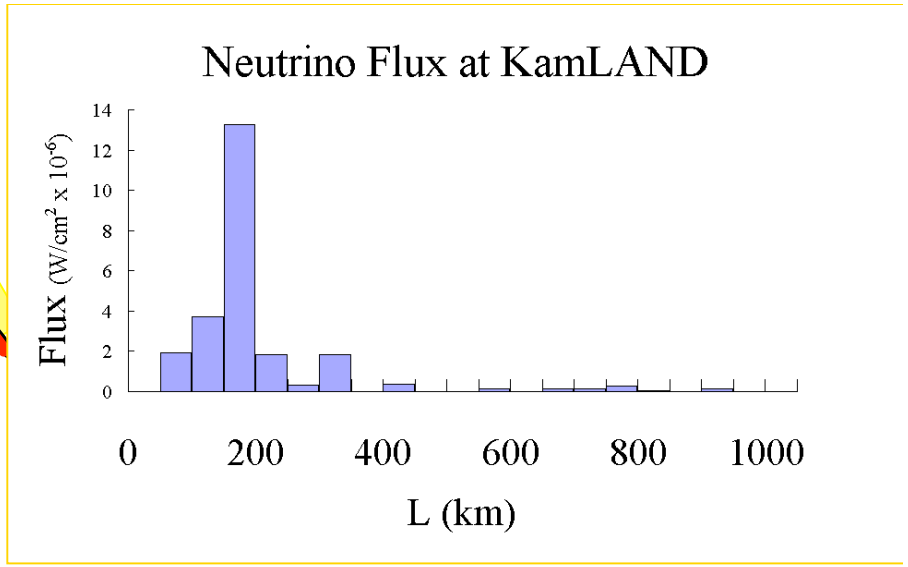

Primorskaya
Russia
Tomari
Asahikawa
Kushiro
Hakodate
Hirosaki
Akita
China
West Asia
South Korea
Onagawa
Kashiwazaki Kariwa
Fukushima Daiichi
Fukushima Daini
Shika
Tsuruga
Fugen
Mihama
Wolsong
Shimane
Toksi
Monju
Hamaoka
Takahama
Ohi
Kori
Genkai
Ikata
Sendai
Ulchin
130°E
132°E
134°E
136°E
138°E
140°E
46°N
44°N
42°N
40°N
38°N
36°N
KamLAND

Site	Distance	# of	P(ther.)	flux	Signal
Japan	(km)	cores	(GW)	($\bar{\nu}$ cm^{-2}s^{-1})	($\bar{\nu}$/yr)
Kashiwazaki	160.0	7	24.6	4.25×10^{5}	348.1
Ohi	179.5	4	13.7	1.88×10^{5}	154.0
Takahama	190.6	4	10.2	1.24×10^{5}	101.8
Hamaoka	214.0	4	10.6	1.03×10^{5}	84.1
Tsuruga	138.6	2	4.5	1.03×10^{5}	84.7
Shiga	80.6	1	1.6	1.08×10^{5}	88.8
Mihama	145.4	3	4.9	1.03×10^{5}	84.5
Fukushima-1	344.0	6	14.2	5.3×10^{4}	43.5
Fukushima-2	344.0	4	13.2	4.9×10^{4}	40.3
Tokai-II	294.6	1	3.3	1.7×10^{4}	13.7
Shimane	414.0	2	3.8	9.9×10^{3}	8.1
Onagawa	430.2	2	4.8	9.8×10^{3}	8.1
Ikata	561.2	3	6.0	8.4×10^{3}	6.9
Genkai	755.4	4	6.7	5.3×10^{3}	4.3
Sendai	824.1	2	3.3	3.5×10^{3}	2.8
Tomari	783.5	2	5.3	2.4×10^{3}	2.0
Korea					
Ulchin	~750	4	11.2	8.8×10^{3}	7.2
Wolsong	~690	4	8.1	7.5×10^{3}	5.2
Yonggwang	~940	6	16.8	8.4×10^{3}	6.9
Kori	~700	4	8.9	8.0×10^{3}	6.6
Total		69	175.7	1.34×10^{6}	1102

Total expected signal from reactors: ≈2 ev/day

S/N ratio ≈ 20 @ 10^{-14} U, Th, ^{40}K contamination in the scintillator

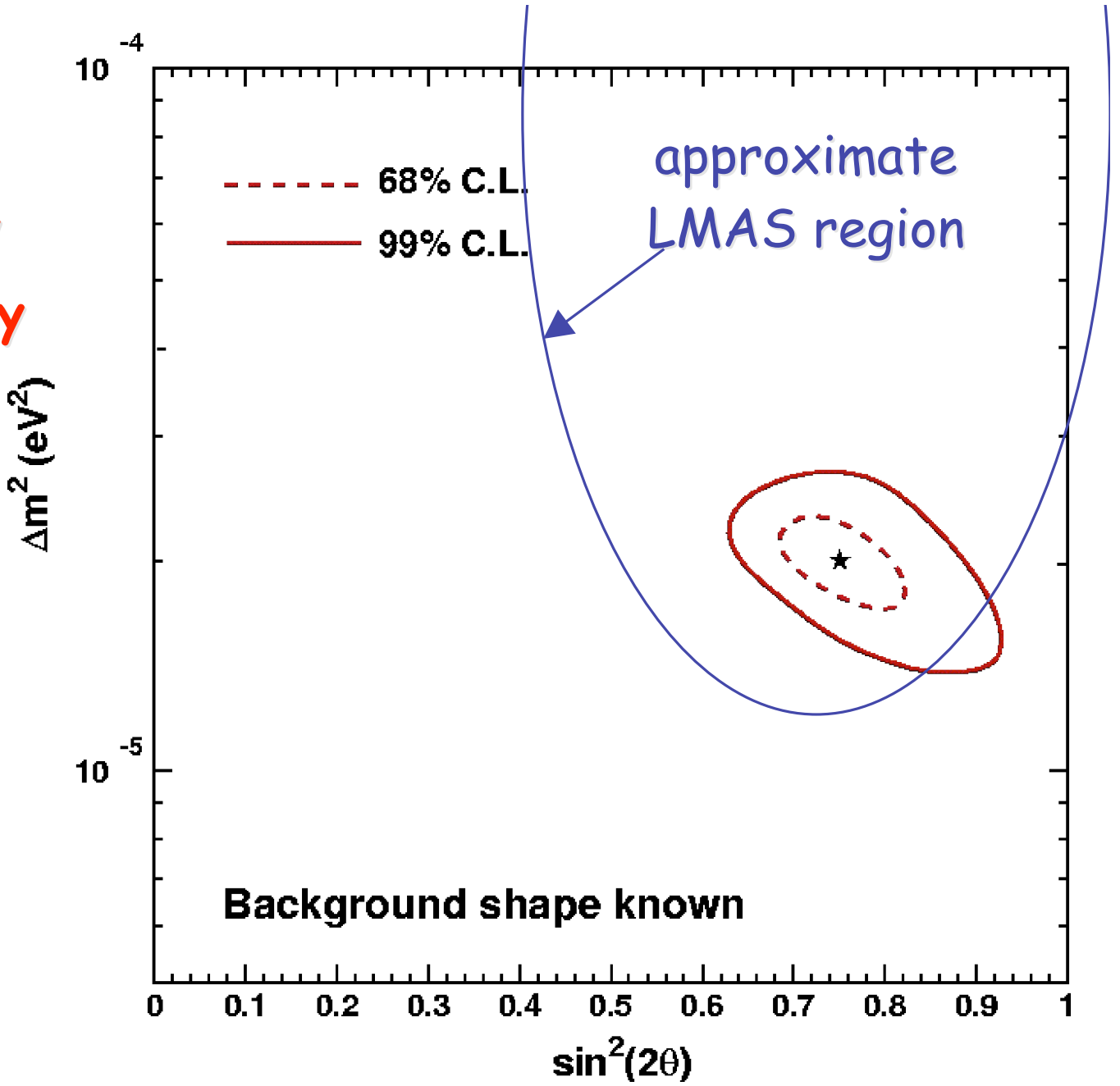
Baseline is limited:
85.3% of signal has
140 km < L < 344 km



The total electric power produced "as a by-product" of the _s is:

- ~60 GW or...
- ~4% of the world's manmade power or...
- ~20% of the world's nuclear power

The ability to measure the solar LMA-MSW solution accurately *"in the lab"* puts KamLAND in a very special category of experiments



Other initial physics topics include:

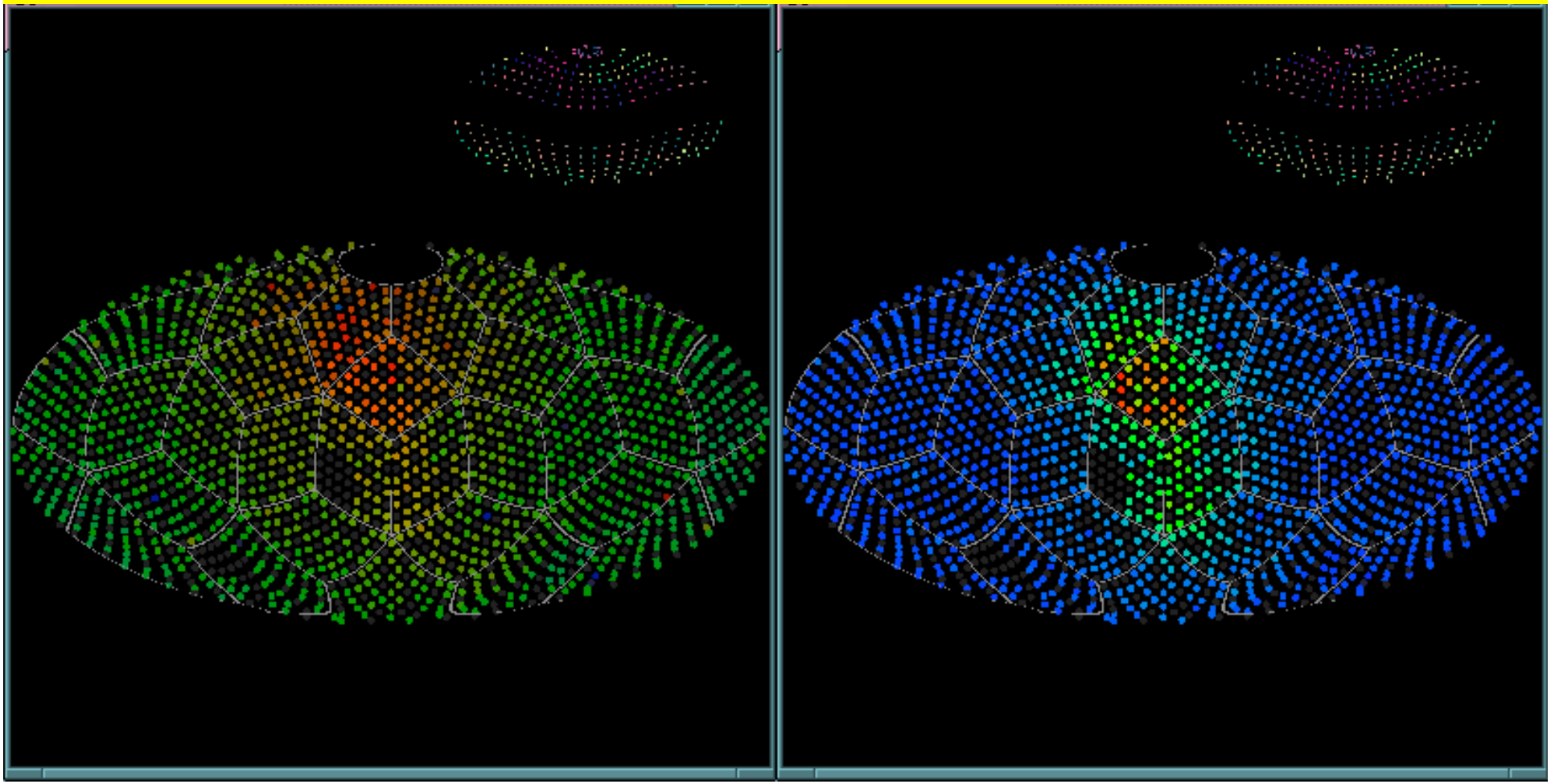
- Geological neutrinos
- Supernovae detection
- Solar anti-neutrinos
- Exotic nucleon decay modes

KamLAND: neutrino physics on a shinkansen

- Summer 2000 — PMT installation
- Winter 2000-01 — Veto counter installation
- Feb 2001 — Balloon insertion
- Mar-Apr 2001 — Balloon inflation and test
- Apr-May 2001 — Plumbing for fill
- Jun-Sept 2001 — Fill MO and LS
- Aug-Sept 2001 — Eng. runs with Macro Elec.
- Sept 2001 — FEE/DAQ/Trigger int. (LBL)
- end Sept 2001 — First data taking with FEE

- Jan 22, 2002 — Begin Data Taking

First muon events, Jan 2002



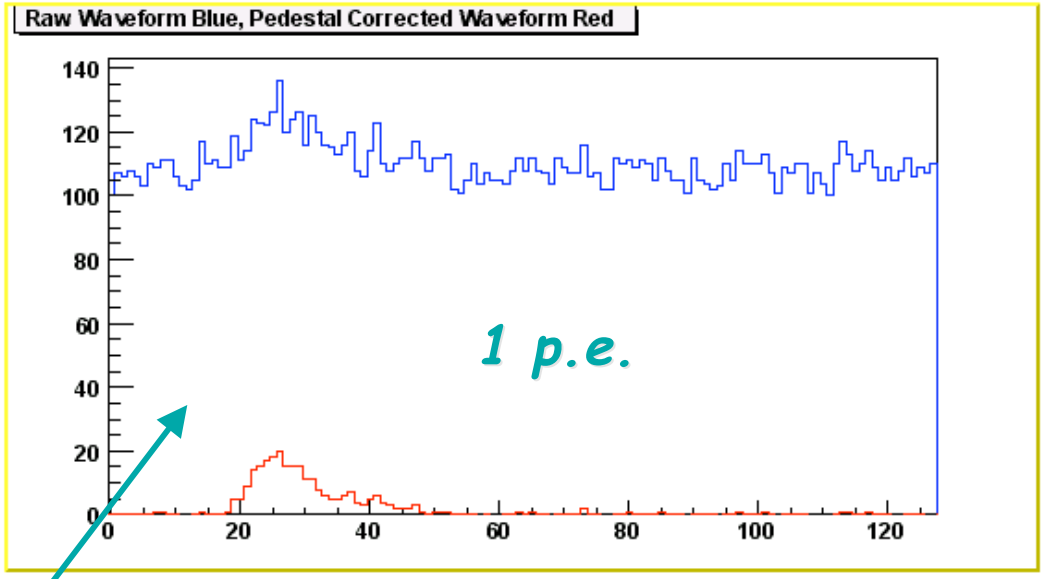
Time: Red soon, Blue late

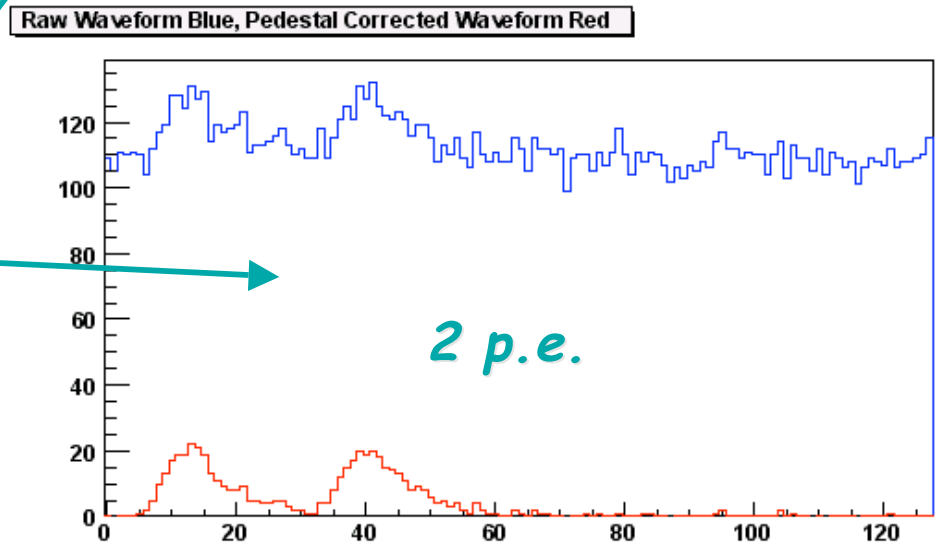
Charge: Red alot, Blue little

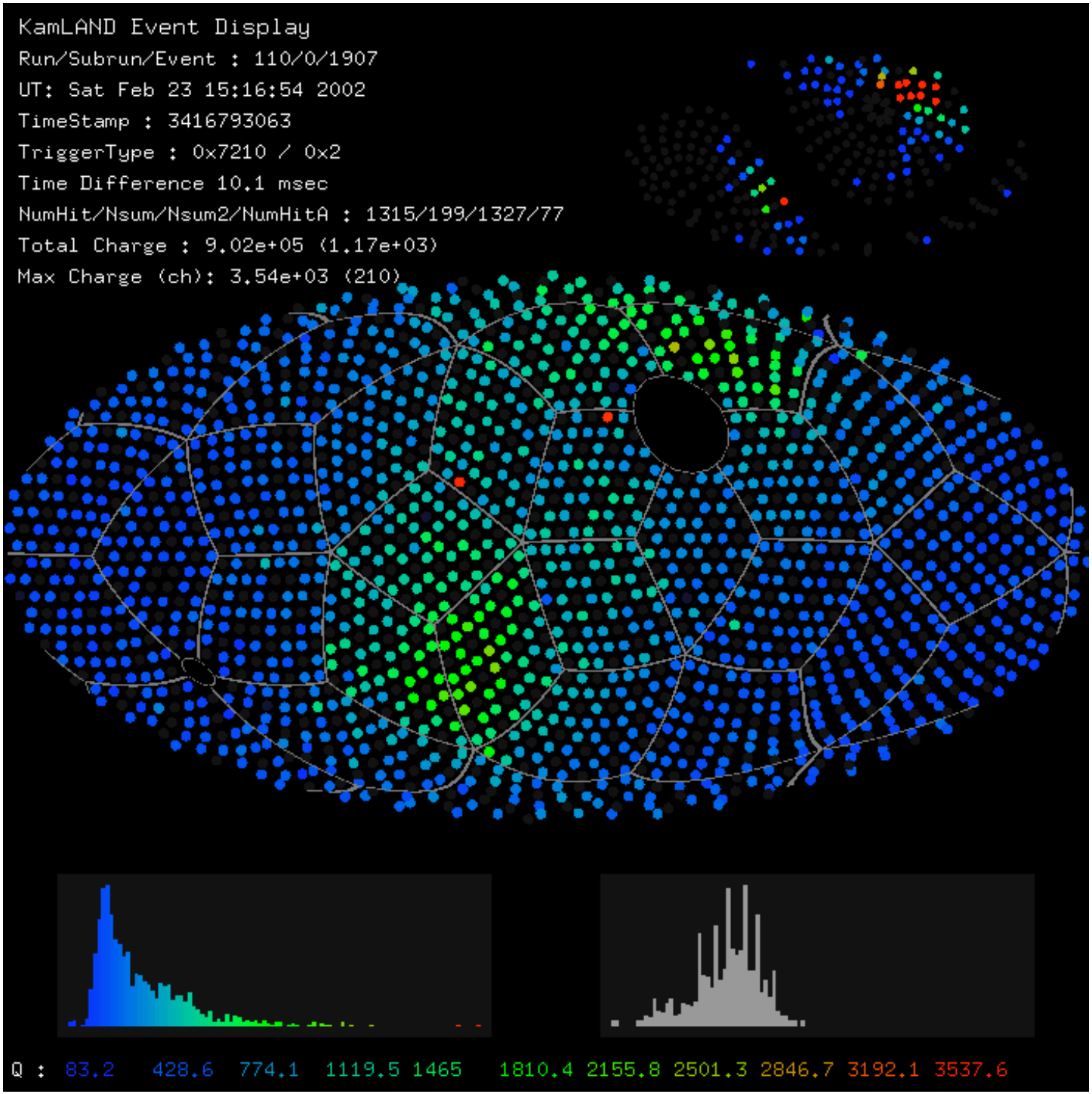
Have full waveform digitizers on every central and veto channel

Very important for exploring new physics and reject complex background signatures

Signals from blue LED flashers in the detector



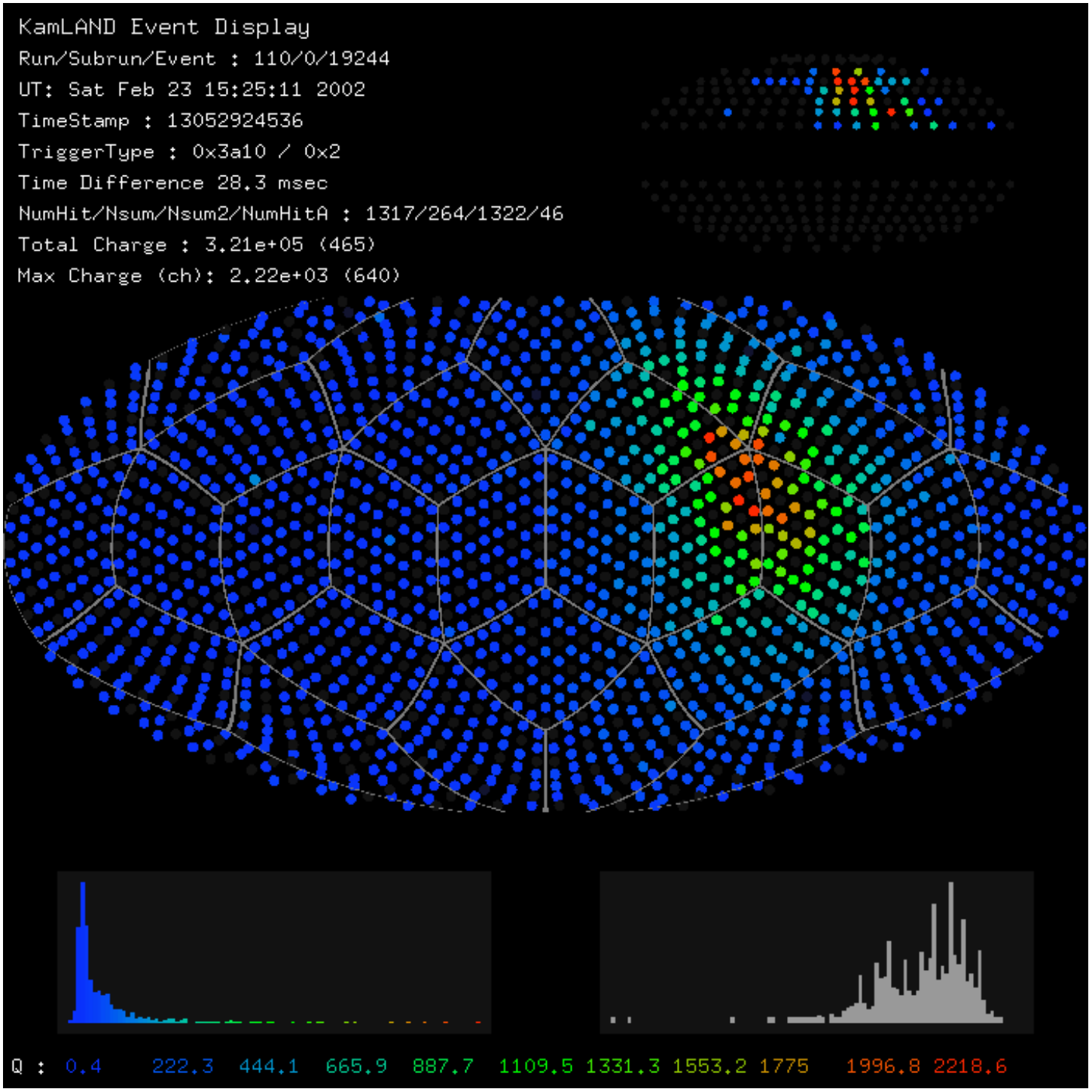




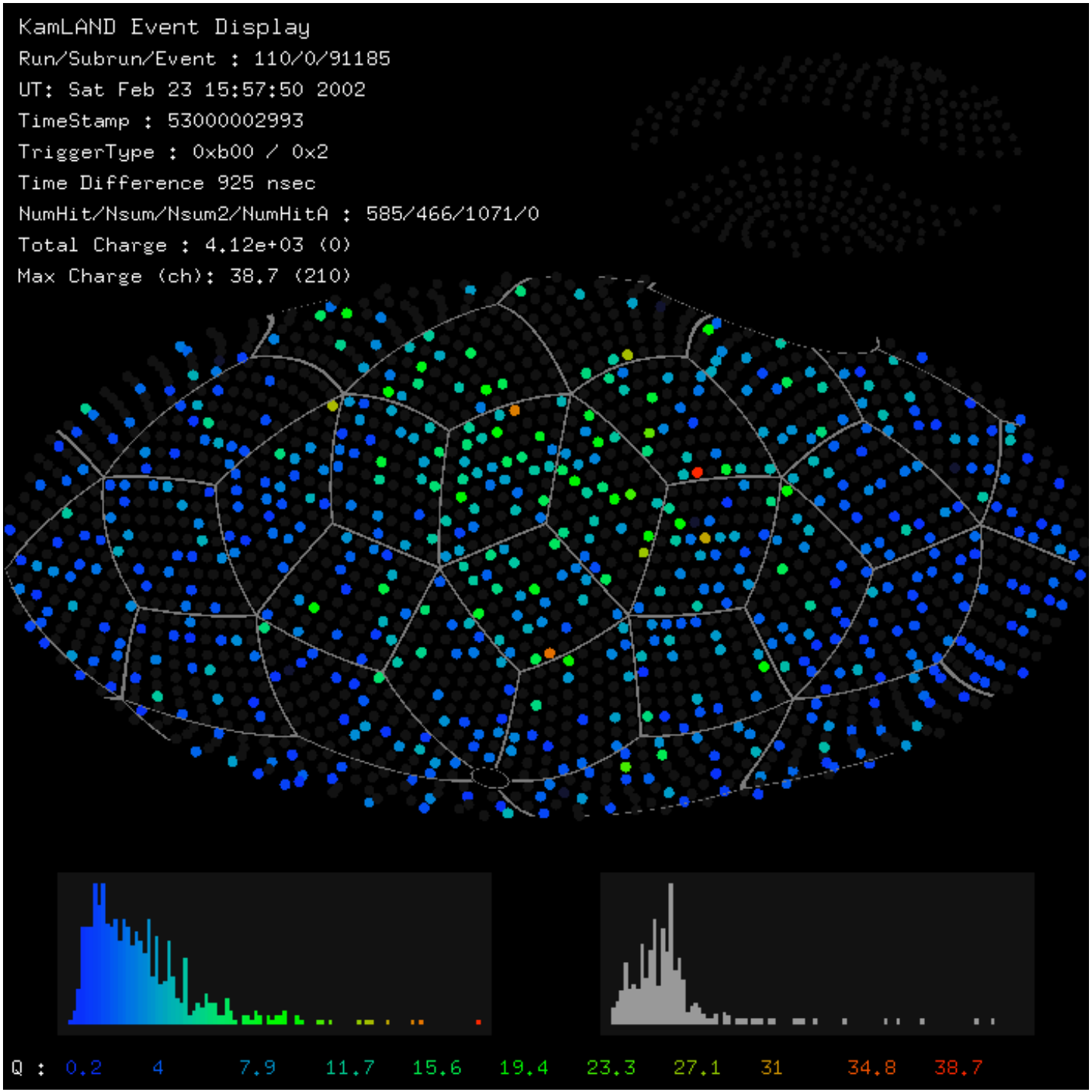
through_going muon

color is pulseheight

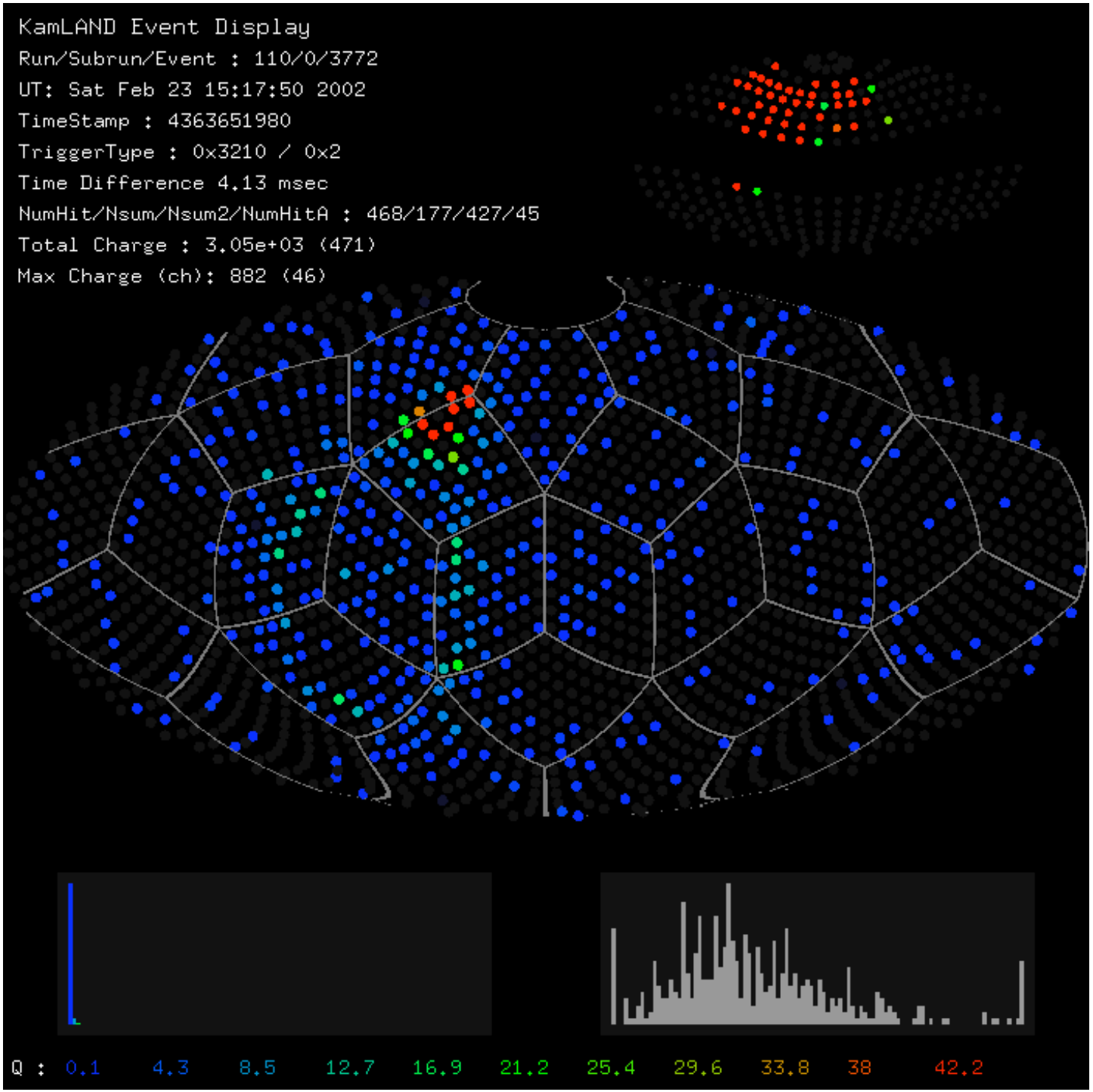
all tubes illuminated



Stopped muon



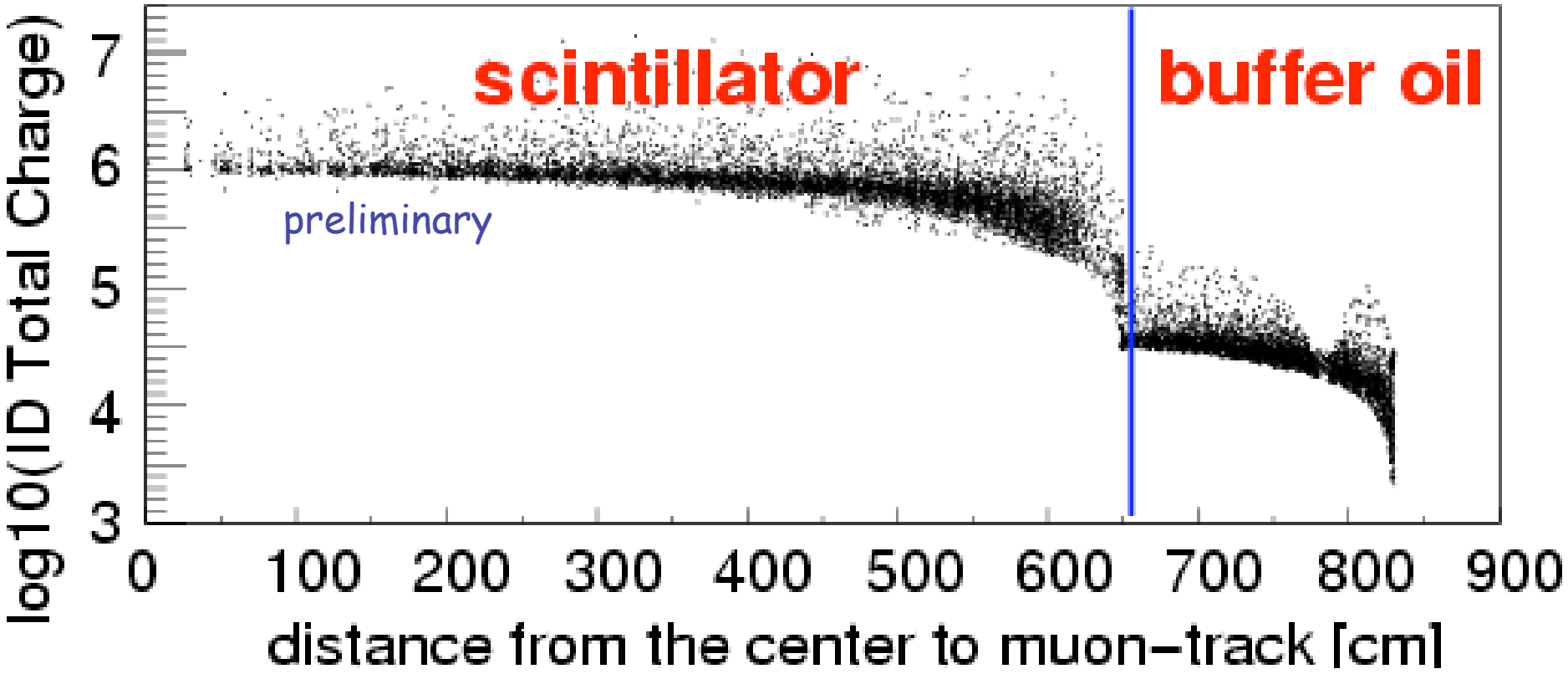
...decaying into a Michel electron

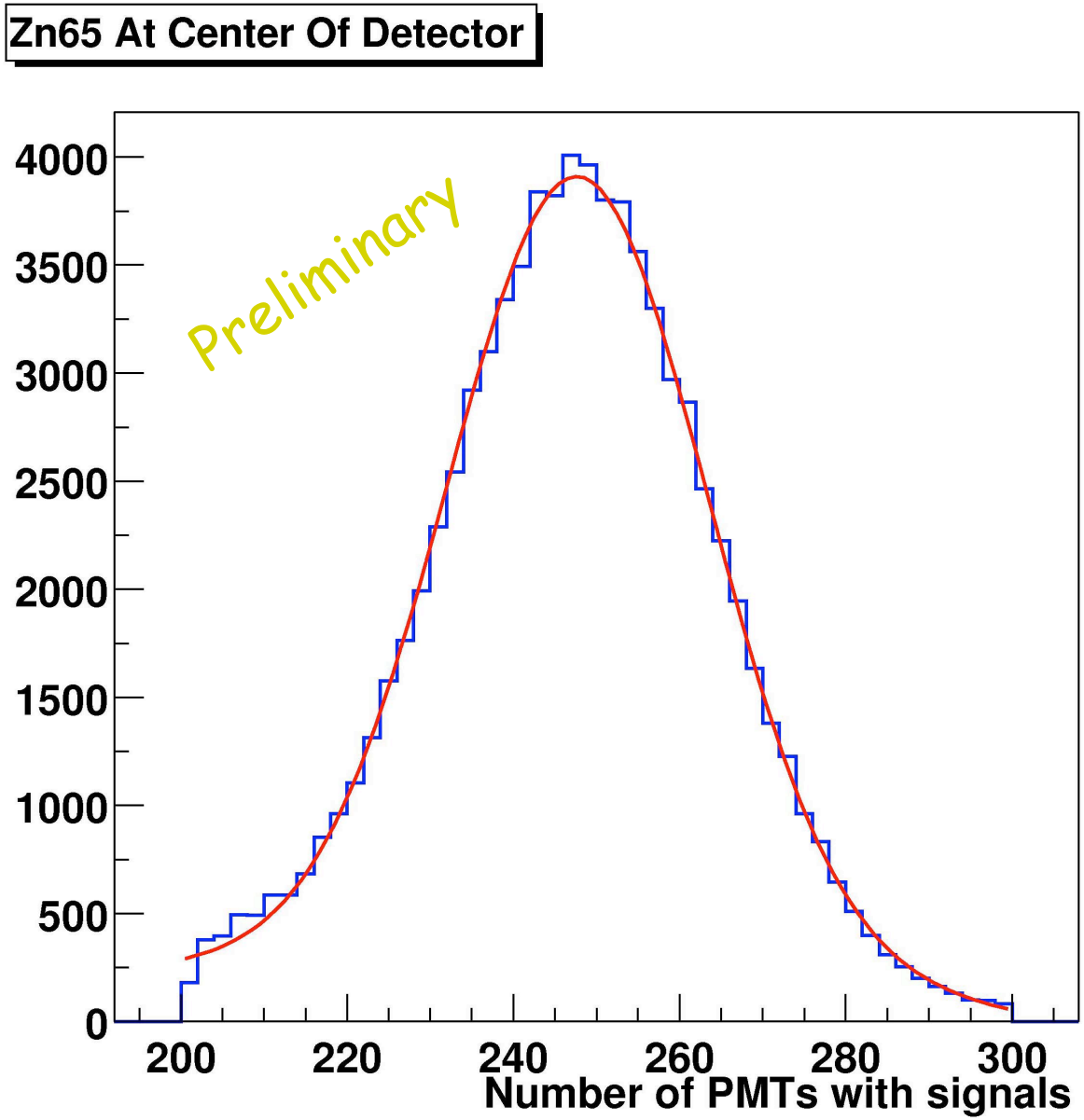


Corner-clipper muon:

Cherenkov ring in the buffer but no scintillation activity

Muon track reconstruction reveals the balloon boundary and the different light yield in scintillator and buffer oil (cherenkov)

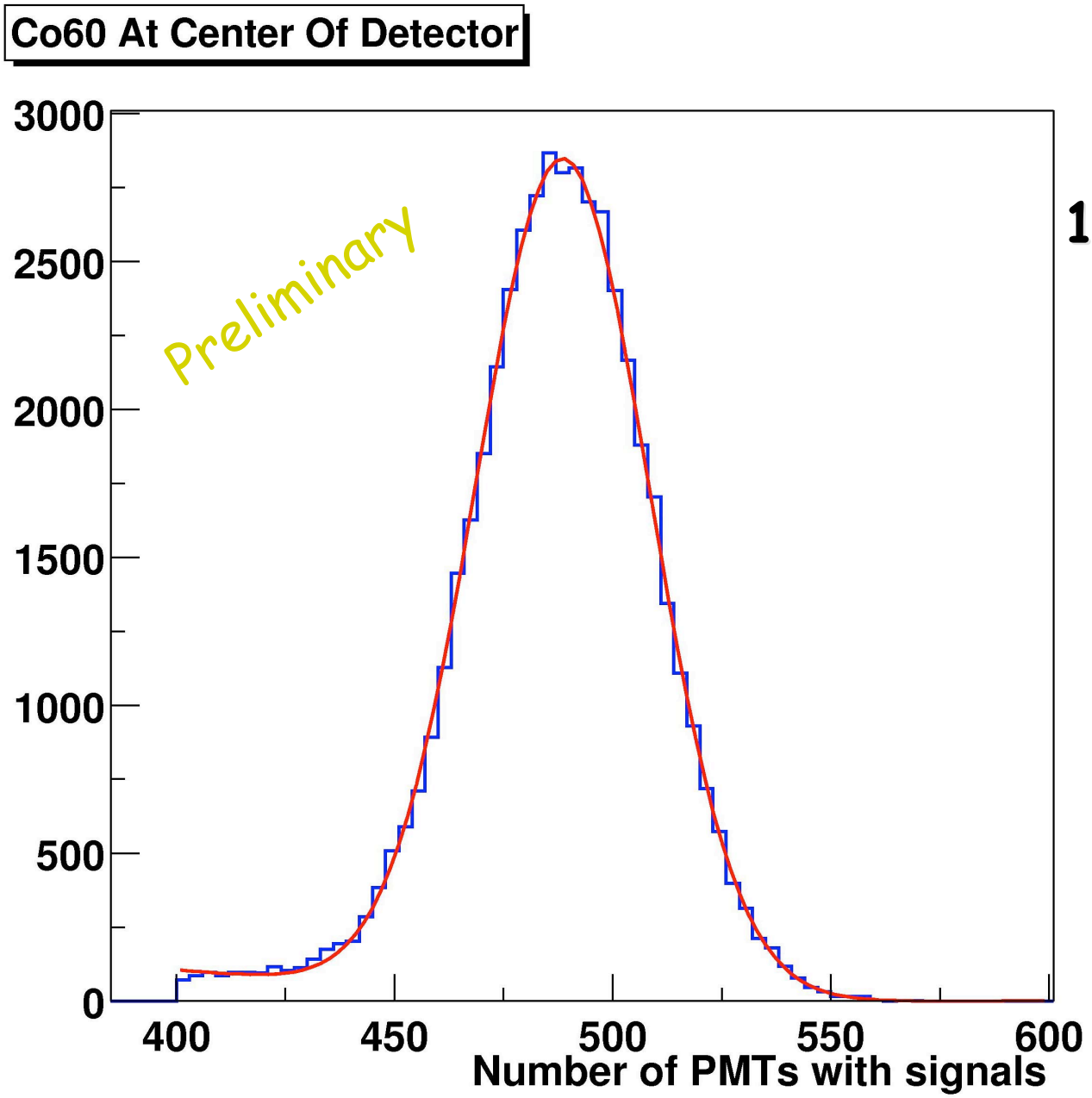




^{65}Zn :
1.115 MeV in
the detector

_/E = 6.5 %

Light Yield
241 p.e./MeV

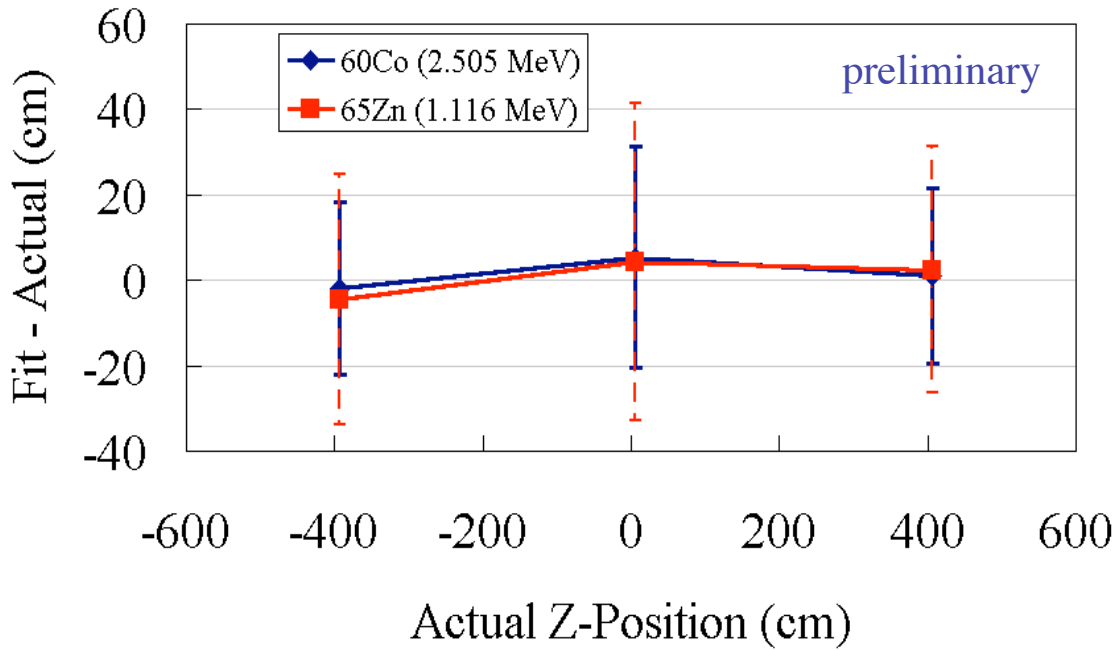


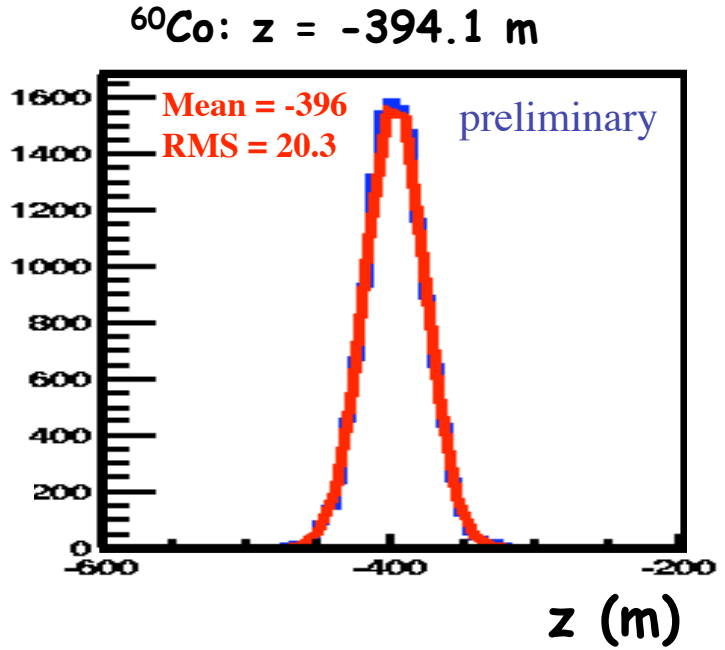
^{60}Co :
1.173+1.333 MeV in the detector

_/E = 4.2%

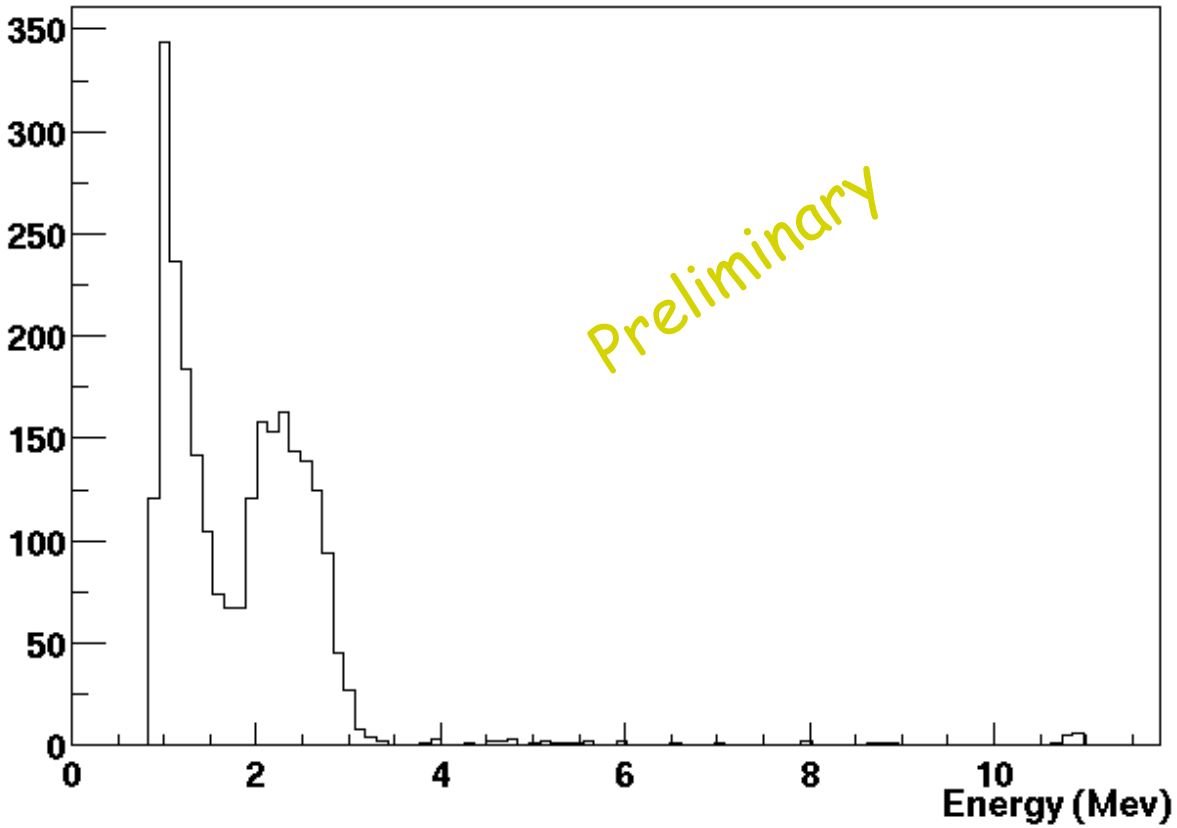
Light Yield
239 p.e./MeV

Position Calibration





Now find cosmic ray muons traversing the detector and look for energy deposits following them

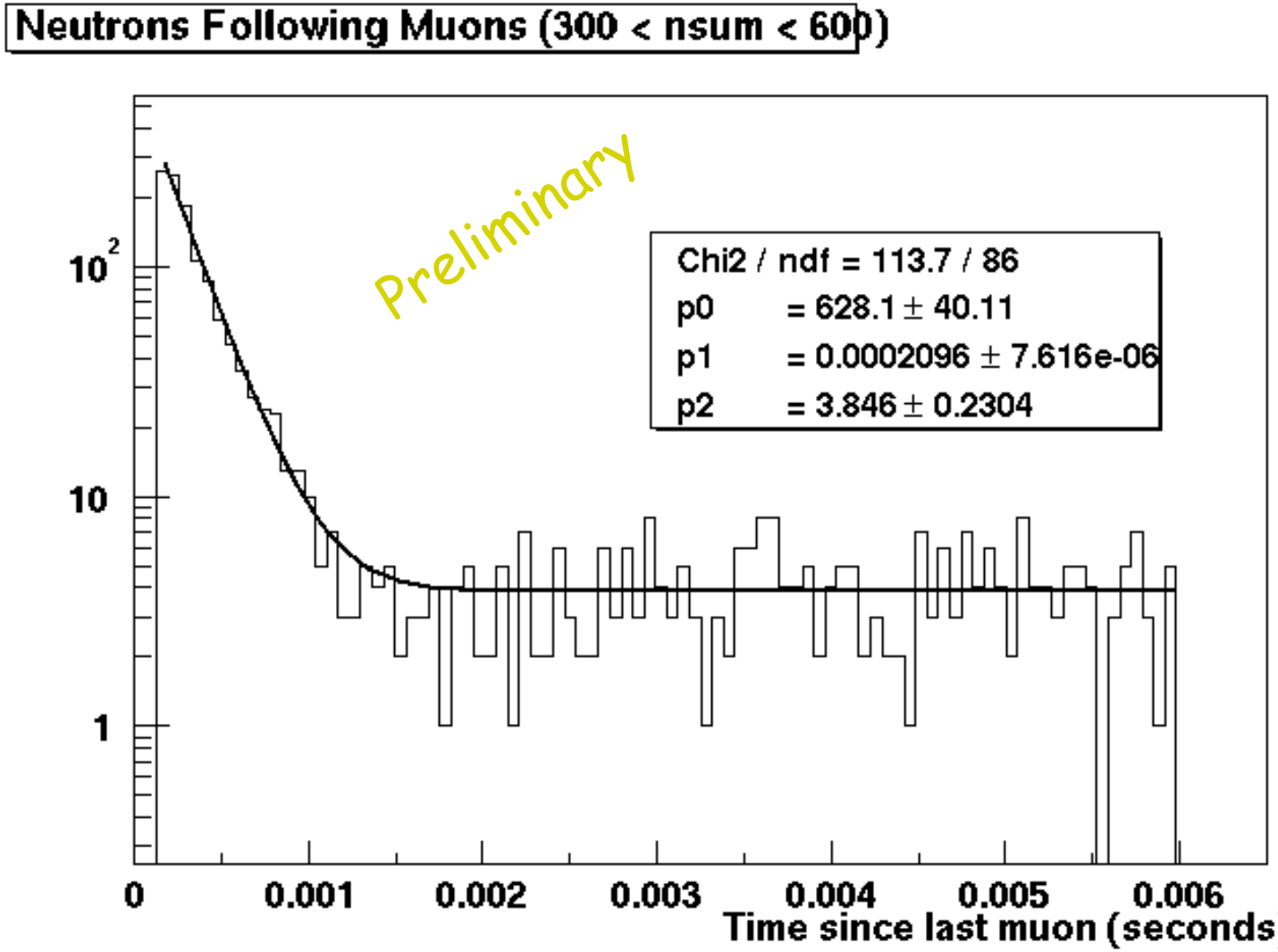


Using E cal. from previous slide the peak is here at ≈ 2.3 MeV

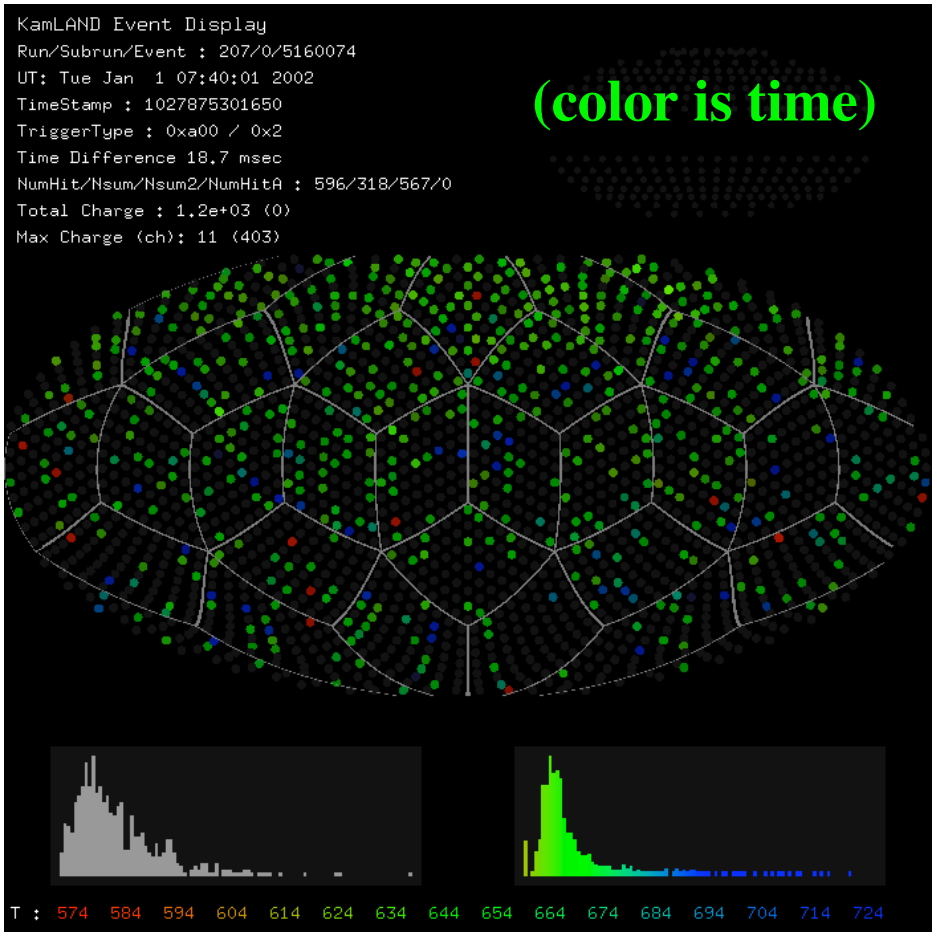
n-capture in hydrogen gives 2.2 MeV

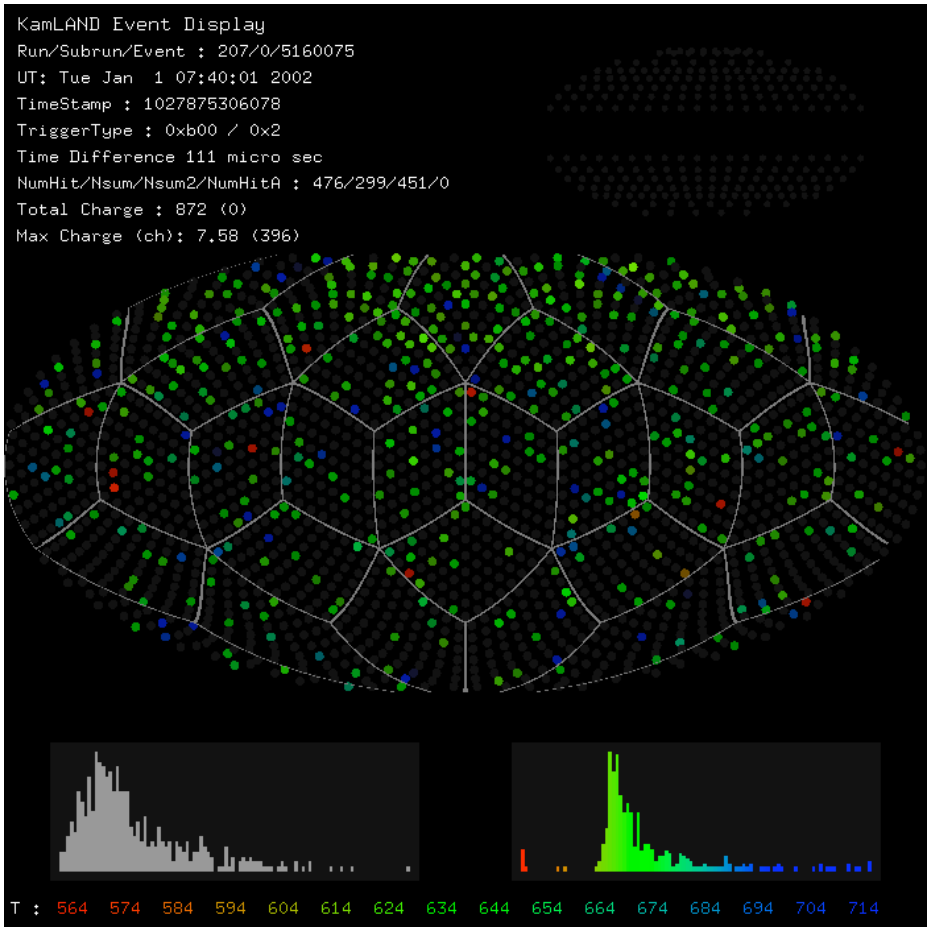
Prompt – delayed correlation time distributed as an exponential with 210±8 _s

Expectation for neutron capture is ~223 _s



Anti-Neutrino Candidate



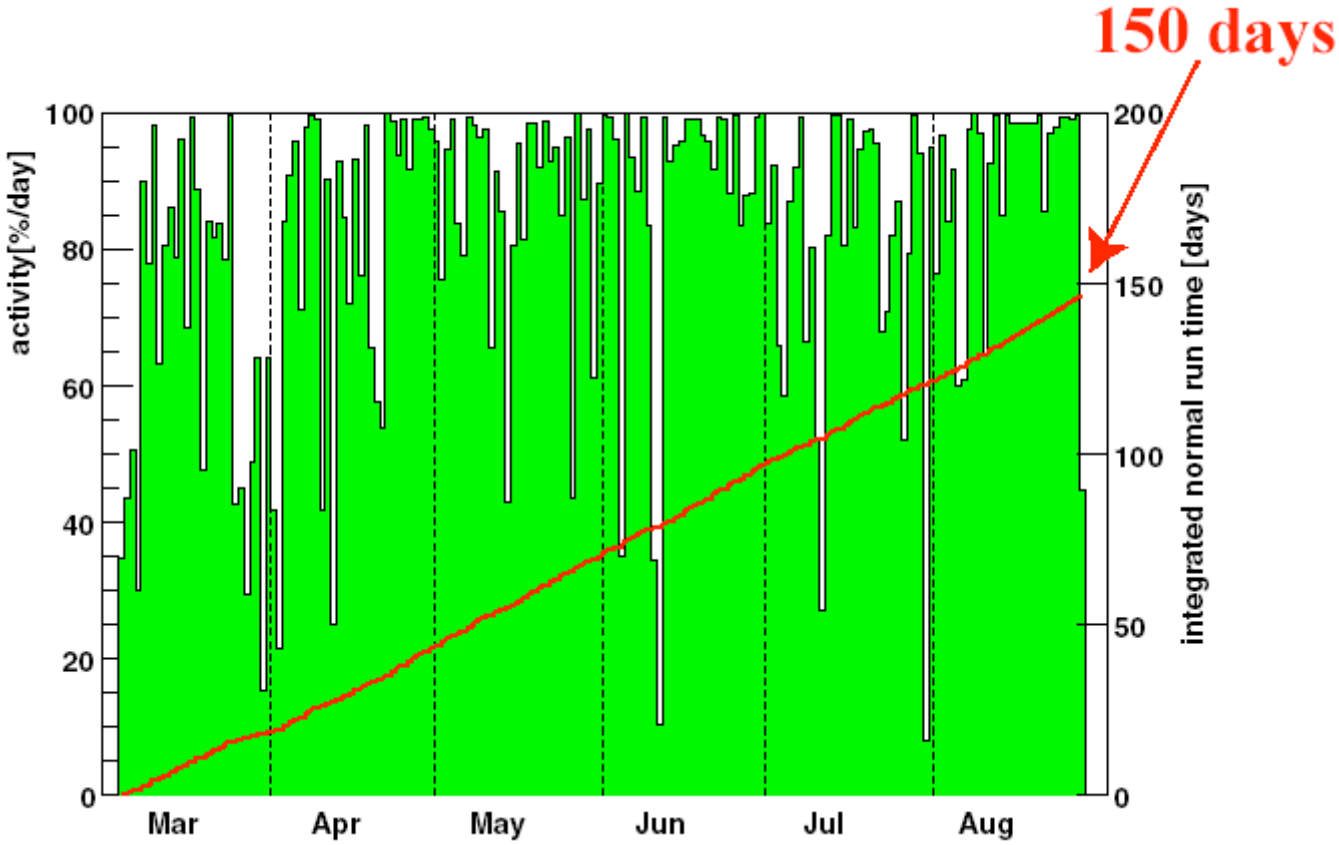


Prompt Signal
E = 3.20 MeV

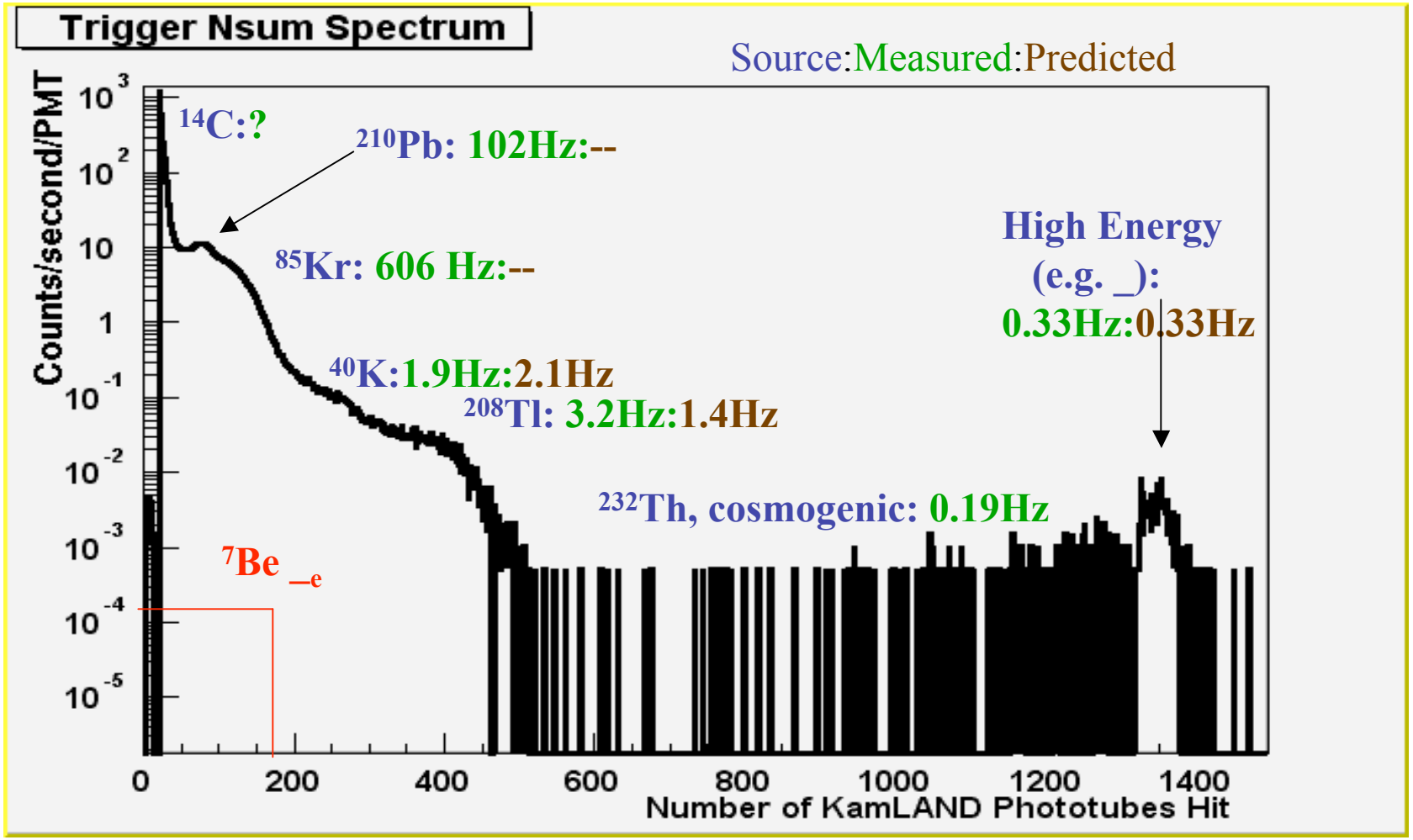
Δt = 111 μs
ΔR = 34 cm

Delayed Signal
E = 2.22 MeV

KamLAND anti-neutrino live-time since the beginning of physics runs



Singles Background



Scintillator contamination by mass

Measured from data:

- Th: using the ^{212}Bi-^{212}Po 300 ns correlation
  - $< 1.8 \times 10^{-16}$ g/g
- U: studying the high energy background
  - $< 6.4 \times 10^{-16}$ g/g
- ^{40}K: fitting background spectra
  - $< 2.3 \times 10^{-16}$ g/g

Consistent with Neutron Activation Analysis:

- Th $< 2.8 \times 10^{-15}$ g/g
- U $< 8 \times 10^{-15}$ g/g
- $^{40}K < 1.3 \times 10^{-15}$ g/g (record NAA sensitivity)

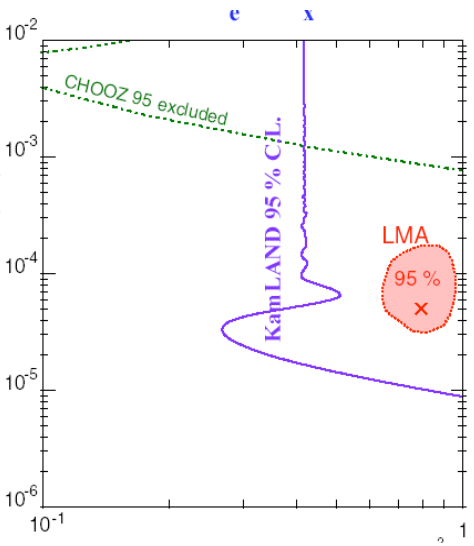
Signal - Background

Flux*CrossSection*LiveTime*Volume*ProtonDensity*CutAcceptance

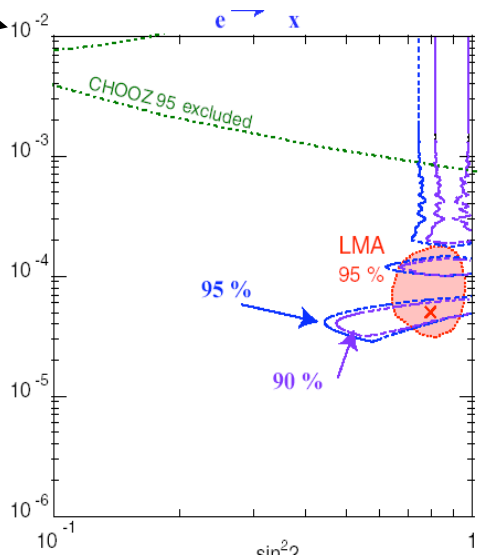
We are in the final stages of evaluating our numbers for all of these quantities and their systematic errors.

No oscillation?

LMA?

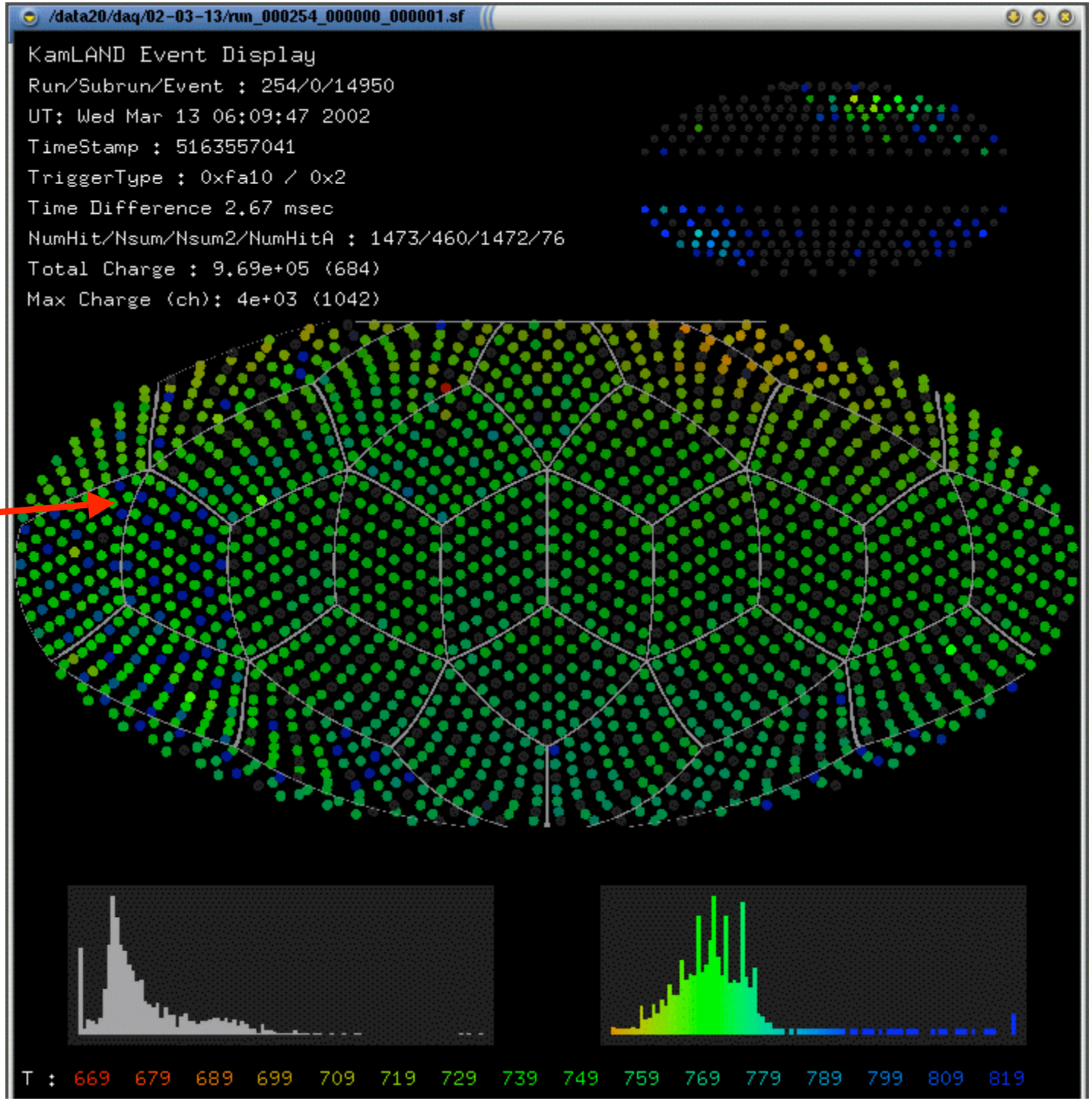


We'll publish the real exclusion plot with our numbers…



20" PMT test, Mar '02

Energy resolution (and data load !!) will improve by ~√2



Oct 11, 2002

Data is coming in smoothly…

stay tuned for many years of exciting results…